REPORT OF EXAMINATION

Robert Revak v. Wagenborg Shipping and Interforest Terminal

Prepared for

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Prepared by

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SUBJECT: Lifting Slings

BACKGROUND

It was reported that on 8 September 2002 lumber products were being unloaded at Pier 80 South in Philadelphia from the hull of the ship Morraborg, using a mobile pier-based crane. The lumber units were reported to have been supported in the unloading process by endless lifting slings of polyester material. Reportedly, as a load was being positioned over the pier, one of the slings parted and the falling lumber injured stevedore Robert Revak who approaching the load as it was being lowered.

It was requested that the circumstances of this incident be evaluated and that an examination be made to determine the nature and the cause of the incident.

SUBMITTED MATERIAL

1. Pleadings, Interrogatories, and Answers to Interrogatories:
   a. Answer with Affirmative Defenses of Defendant Interforest Terminal UMEA AB to the Plaintiffs' Amended Complaint (filed 17 February 2004).
   b. Second Amended Complaint (filed 01 July 2004).
   c. Plaintiffs' Complaint—Revak v. Wagenborg Shipping B.V. (filed 08 September 2004).
   d. Plaintiff's Answers to Interrogatories of Defendant Wagenborg.
   e. Plaintiffs' Supplemental Answers to Interrogatories of Defendant Wagenborg Shipping B.V.

2. Depositions:

   a. Robert Revak, dated 1 June 2006.
   b. Captain Ferdinand Bijkerk, dated 17 August 2006.
   c. Chief Officer Martinus Lukassen, dated 17 August 2006.
   d. Koert Kuursta, dated 18 August 2006.
   e. Robert Strijland, dated 18 August 2006.
   f. Leif Eriksson, dated 21 August 2006.
   g. Patrick Mattsson, dated 21 August 2006.
   h. Urban Häggkvist, dated 21 August 2006.
   i. Pierre Ogren, dated 22 August 2006.
   j. Per Johansson, dated 22 August 2006.

3. Deposition Exhibits:

   a. P-1 Document of Compliance
   b. P-2 September 9, 2002 Telex and Certification
   c. P-3 August 27, 2002 Telexes
   d. P-4 Statement of Facts -Eemshaven
   e. P-5 Statement of Facts -Holmsund
   f. P-6 Statement of Facts -Kotka Finland
   g. P-7 General Arrangement Plan of the M/V Morraborg
   h. P-8 Interforest "Vessel Specification" dated August 24, 2002
   i. P-9 Report of Marine Accident
   j. P-10 Statement of Facts Master and Chief Officer
   k. P-11 Unsigned General Report
   l. P-11A Signed General Report
   m. P- 12 Master's Statement of Protest dated September 8, 2002
   n. P-13 Email from Interforest to Master dated August 26, 2002
   o. P-14 Stowage Material Report
   p. P-15 Cargo Stowage Plan
   q. P-16 Notes regarding loading at Holmsund
   r. P- 17 Master's Delivery Note of August 24, 2002 regarding slings
   s. P-18 Ship's Particulars
   t. P-19 Notes regarding September 8, 2002 discharging operations
   u. P-20 Crew List
   v. P-21 Stow Plan for Deck Cargo
   w. P-22 Excerpts from Port Log dated August 1, 2002 through September 8, 2002 pp. 89-95
   x. P-23A Photograph of Ship

y. P-23B Photograph of Stow
z. P-23C Photograph of Stow
aa. P-23D Photograph of Stow
bb. P-23E Photograph of Stow
cc. P-23H Photograph of Scene on Dock
dd. P-23I Photograph of Scene on Dock
ee. P-23J Rescue Efforts Photograph
ff. P-23L Package Label Photograph
gg. P-23M Photograph of Rescue Team
hh. P-23N Photograph of Scene on Dock
ii. P-23O Photograph of Scene on Dock
jj. P-23P Photograph of Mate and Apprentice Standing on Dock
kk. P-24A Photograph of Broken Sling on Dock
ll. P-24B Photograph of Broken Sling on Dock
mm. P-24C Photograph of Broken Sling on Dock
nn. P-24D Photograph of Cut Sling on Dock
oo. P-24E Photograph of Broken Sling
pp. P-25 2 photographs of the ship taken on September 9, 2002
qq. P-26 1 photograph of the shore crane taken on September 9, 2002
rr. P-27 Erb Photographs
ss. P-27A Erb Photographs
tt. P-27B Erb Photographs
uu. P-27C Erb Photographs
vv. P-28 Cargo Securing Manual
ww. P-29 Portions of the Shipboard Operation Manual
xx. P-30A Locatum Invoice 65307 8/15/02-8/23/02
yy. P-30B Locatum Invoice 65317 8/23/02-10/11/02
zz. P-30C Locatum Invoice 65603 11/01/02-11/07/02
aaa. P-31 Interforest Inventory of Slings

4. Standards Documents:

a. European Standard EN 1492-1 : 2000; DIN (Deutsches Institute für Normung e. V.) Standard: Textile Slings—Safety. Part 1: Flat woven webbing slings made of man-made fibres, for general purpose use. English version of DIN EN 1492-1.
b. ASME B30.9c-2000 (American Society of Mechanical Engineers): Chapter 9-5, Synthetic Webbing Slings—Selection, Use, and Maintenance.

EXAMINATION

On 17 April 2003 I visited the offices of Edward J. Powers, Vandeventer Black LLP, Norfolk, Virginia to examine the flat webbing sling involved in the accident. The purpose of this examination was to observe conditions, obtain measurements and take photographs. For examination the 7-meter sling was laid out on a conference table. The sling had two discontinuities—one being the break causing the accident and one that was deliberately cut while freeing Mr. Revak. I inspected the length of the sling, approximately 46 feet. I also took photographs—including macro photos—of various parts of the sling. Four of these photographs have been presented as Plaintiffs' Exhibits P-27, P-27A, P-27B and P-27C. Five other photographs are described in this section and are listed as enclosures at the end of this report. A CD is available with a complete set of images taken, which is part of this report.

My examination was primarily concerned with two subjects:

(1) the overall condition of the sling—including indications which would call for withdrawal from service; and

(2) the failure site.

Sling.

The sling was old and well worn. Much of the green coating by which it was identified under European Standard EN 1492-1 as having a working load limit of 2.0 metric tons was worn off. Many areas of the sling were dirty.

The standards-specified label was missing.

Enclosure 1 shows localized abrasion damage to the face of the sling. In the discolored damage area the top layer of fibers is destroyed, leaving fuzzy remnants. This localized abrasion damage was readily visible. The remaining area on the sling shows the green color coating worn away by chafing.

Enclosure 2 shows another area of localized abrasion damage to the face of the sling. This damaged area is on a diagonal across most of the width of the sling.

Enclosure 3 shows edge damage to the sling. Some fiber bundles were completely broken through and some unraveling has occurred. This type of damage was readily visible.

Enclosure 4 shows another example of edge damage on the subject sling. This damage extended to about 50 mm along the edge.

Failure Site.

Enclosure 5 shows the sling on both sides of the failure site. The process of pulling apart began on the side next to the millimeter ruler. Short fibers extended toward the break on that half of the sling. This indicates that there was damage to the fabric in that area prior to the failure. As a consequence, elongation before rupture was reduced in that area. With the failure of one-half of the sling, the remaining portion came under increasing tensile stress as it supported the load of lumber.

The next section then began to fail, leaving longer fibers protruding at the break. Then finally the entire load was "hanging by a thread," the long strand at the edge, which finally broke.

An examination of the areas of the sling near the break supports this failure mode. The failure site exhibits *both* edge damage and abrasive damage to the face. The edge area adjacent to 6.2 on the ruler is discolored and is degraded to the point that the multifilament threads have lost their form. Further away from the ruler there continues to be damage to the face of the sling.

The defects shown on Enclosures 1 through 5 are types that would have been readily visible during a reasonable inspection of the sling prior to the accident.

OPINIONS

The opinions, bases of opinions and interpretation of examined evidence are stated to a reasonable degree of scientific certainty, based upon my experience, my examination, and the materials and standards reviewed.

- Interforest Terminal personnel had at least four opportunities to perform the required inspection of the subject sling, and to detect the damaged and defective sling condition, and remove the sling from service.

  (1) when the ship unloaded the slings after a return voyage and the slings were collected and moved by Interforest personnel to the depot;

  (2) when the slings were bundled by Interforest personnel in bundles of ten at the depot (Eriksson deposition 16-3;19-2);

  (3) when Interforest personnel opened the bundles of ten at the pier and unfolded them; and

(4) when the Interforest stevedores placed the slings around each load.

- The subject sling had multiple sites of readily visible edge damage and multiple sites of abrasion damage to the face that should have been detected with a reasonable visual inspection. Prior to the application of the sling in Sweden, the worn and damaged condition of the sling reduced the factor of safety to carry the subject load; therefore, the sling should have been removed from service.

- A cursory examination by a suitably trained person would have revealed that the label was missing—a cause for immediate withdrawal of the sling (EN 1492-1 : 2000, Section B-7 a).

- Interforest Terminal has not produced periodic records of examination as required by EN 1492-1 : 2000, Section B-7 b.

- Shipboard Wagenborg personnel had reasonable and adequate opportunity to inspect and withdraw from service the subject sling from one or more previous return voyages. The subject sling had multiple sites of edge damage and multiple sites of abrasion damage to the face that could have been detected with visual inspection. A cursory examination by a suitably trained person would have revealed that the label was missing—a cause for immediate withdrawal of the sling (EN 1492-1: 2000, Section B-7 a).

- Considering the obvious age and condition of the subject sling it is evident that both Wagenborg and Interforest had not just one, but many cycles of the listed opportunities to detect the withdrawal-worthy defects in the subject sling.

  - This is not to suggest that the only duty that Wagenborg had to inspect the slings was on previous return voyages. The extent of Wagenborg's duty to inspect is not a subject for this report. My opinions are limited to the inspections actually made by Wagenborg and do not encompass the full extent of any duty they may have had to inspect.

- The inspections and examinations by Interforest and Wagenborg personnel failed to reject—withdraw from service—the subject sling even though:

  (1) it was seriously and visibly worn and damaged and

  (2) clearly lacked its label and legible markings.

- The subject sling showed multiple locations of serious surface abrasion and of damaged edges. The sling failed at a place along its length in which both surface abrasion and edge damage had been present.

- The defect that led to the failure could have been detected by a proper visual inspection prior to the accident.
- Allowing this badly worn and damaged sling to continue in service was a direct cause of this accident.

BASES OF OPINIONS

Basics: The nature of aging and wear for a sling.

Simple stretching—with longitudinal force—of a woven sling is not the primary cause of aging and wear. A force somewhat less than the WLL (working load limit, 2 metric tons) can be repeated hundreds of cycles in simple tension without any significant aging or wear.

The "real-world" situation for a lifting sling is quite different. The sling rubs against objects—particularly against parts of the load being lifted—during each lifting cycle.

The endless sling loops under a solid base. The top of the sling is hung on a hook on a spreader. Just before the crane begins lifting the load, the sling becomes taut. Then as tension increases, while the object is still on its substrate (the surface of the pier for loading, and inside the hold for unloading) the woven polyester sling begins to stretch. As it does so parts of the sling slide past the right-angle edges of the rigid base of the load. This friction can cause chafing, which in the early life of a sling may do no more harm than rubbing off some of the colored WLL-identifying coating. However, more serious wear—localized abrasion wear—commonly occurs. This abrasion wear was seen in the examinations described above for the subject sling. Examples of this abrasion wear are shown in Figures 1 and 2 (Section 1: Examinations).

The endless slings are able to be looped under a load of lumber because it is supported on two boards in order to allow a fork-lift to slide in or out under the load as it sits on a flat surface. The slings, for safe lifting, are placed in under the load as far as is practical—that is, close to these boards. (Johansson deposition 36-13.) During a given lifting event, as the slings stretch under tension, the inner, board-contacting edge of the sling rubs against the sharp ends of the boards and experiences abrasion damage with serious fiber breakage, such as that shown in Figures 3 and 4 (Section 1: Examinations).

Various environmental factors adversely affect the slings. The sling material is reported to be polyester (P-2). The polyester generally used in textile products is polyethylene terephthalate (PET). It has been produced under various trade names, such as Dacron and

Terylene. As with most organic polymers, PET can experience photo-oxidative (UV) degradation with exposure to sunlight. The tensile strength of the fiber material (normally 7000 to 15000 psi) and the elongation at break (normally 30 to 300%) are diminished by photo-oxidative degradation, which contributes to the weakening of certain slings by wear.

European Standard EN 1492-1 : 2000 (Section D.1.3) states: "Flat woven webbing slings should not be exposed or stored in direct sunlight or sources of ultra-violet radiation." The age of the subject sling is presently unknown (the label for traceability is missing), but it has a "very old" appearance. The sling was exposed to the sun while repeatedly at pier-side or elsewhere.

Another environmental factor affecting wear is dirt—in particular the silica or other mineral dust susceptible to being picked up when the slings lay on the loading or unloading piers. Dirt between the fibers increases certain abrasion-type frictional wear.

Accepted Industry Standards for Examination and Inspection of the sling.

Wagenborg Shipping and Interforest Terminal were not compliant with either the European or the American safety requirement standards for lifting slings.

European standards

Written standards were in force in 2002 in Europe for endless polyester woven slings. European Standard EN 1492-1 : 2000 is titled: "Textile slings—Safety; Part 1: Flat woven webbing slings made of man-made fibres, for general purpose use; English version of DIN [Deutsches Institute für Normung] EN 1492-1. This European Standard was approved by CEN [European Committee for Standardization] on 25 June 2000. CEN members are the national standards bodies of Finland, Sweden, the Netherlands, and 16 other European nations.

This European standard specifies the requirements related to safety— including methods of rating and testing—endless sewn flat woven webbing slings made of polyamide, polyester and polypropylene man-made fiber webbing in the width range of 25 mm to 450 mm inclusive. It thus covers the subject sling, designated as Type A, WLL 2.0.

The EN 1492-1 standard includes requirements for marking the sling and directions for periodic thorough examination and withdrawal criteria.

Standard EN 1492-1: 2000 stated:

- Page 15. **5.16 Traceability code.** The traceability code, which is to be included in the marking (see 7.1), shall enable at least the following basic elements of the manufacturing record to be traced:

  a) identification of webbing;

  b) identification of manufacturer's control;

  c) identification and grade of fittings.

- Page 17. **7 Marking.**

7.1 General.

The marking of the sling shall include at least the following:

a) the working load limit, in straight lift;

b) the material of the webbing, i.e. polyester, polyamide, polypropylene;

c) grade of fitting;

d) the nominal length in m;

e) the manufacturer's name, symbol, trade mark or other unambiguous identification;

f) the traceability code (see 5.16);

g) the number and relevant part of this European Standard.

- Page 17. **7.2 Sling types A, B, C and Cr**

7.2.1 The information shall be marked (in accordance with 7.1) both legibly and indelibly, on a durable label fixed directly onto the webbing. It shall be marked in a type size of not less than 1.5 mm in height.

7.2.2 The material from which the webbing is made shall be identified by the colour of the label itself on which the information is marked. The following label colours shall be used:

- Polyamide green
- Polyester blue
- Polypropylene brown

- Page 19. **Figure 4—Typical attachment of label on an endless sling**
- Page 23, 24. **Annex B (normative)**

Information for use and maintenance to be provided by the manufacturer

B.2 General

The manufacturer of flat woven webbing slings shall provide documented information, covering the subjects listed below, with each commercially indivisible batch of slings.

B.4 Before putting the sling into first use (see D.2.1)

a) availability of manufacturer's certificate;

b) availability of instruction and training.

B-5 Before each use/period of use (see D.2.2 and D.2.3)

a) inspection procedure;

b) presence of label and legibility of marking;

c) withdrawal criteria.

B-7 Periodic thorough examination and maintenance

a) withdrawal criteria including missing/damaged label or illegible marking;

b) records of examination.

- Page 26, 27, 30. **Annex D (informative)**

Suggested content of information to be provided by the manufacturer with flat woven webbing slings

D-2 Inspection of flat woven webbing slings in service

D.2.2 Before each use the sling should be inspected for defects and to ensure that the identification and specification are correct. A sling that is unidentified or defective should never be used, but should be referred to a competent person for examination.

D.2.3 During the period of use, frequent checks should be made for defects or damage, including damage concealed by soiling, which might affect the continued safe use of the sling. ... If any doubt exists as to the fitness for use, or if any of the required markings have been lost or become illegible, the sling should be removed from service for examination by a competent person.

The following are examples of defects or damage likely to affect the fitness of slings for continued safe use:

a) Surface chafe. In normal use some chafing will occur to the surface fibres. This is normal and has little effect. However, the effects are variable and as the process continues, some loss of strength should be expected. Any substantial chafe, particularly localized, should be viewed critically. Local abrasion, as distinct from general wear, can be caused by sharp edges whilst the sling is under tension, and can cause serious loss of strength.

b) Cuts. ... cuts or chafe damage to selvedges ...

D.3.14 Prior to placing in storage, slings should be inspected for any damage which may have occurred during use. Slings should never be returned damaged to storage.

D-4 Examination and repair

Examination periods should be determined by a competent person, taking into account the application, environment, frequency of use and similar matters, but in any event slings should be visually examined at least annually by a competent person to establish their fitness for continued use.

Records of such examinations shall be maintained.

Damaged slings should be removed from service.

B. American Standards

The American Society of Mechanical Engineers has provided standards for webbing slings. These standards closely parallel the European standards described above. Industry application for standards for lifting slings ensure safety.

ASME B30.9c-2000: Chapter 9.5 stated:

Synthetic Webbing Slings—Selection, Use, and Maintenance.

Section 9-5.5: Sling Identification

9-5.5.1 Marking Requirements. Each sling shall be marked to show:

(a) name or trademark of manufacturer

(b) manufacturer's code or stock number

(c) rated load for the types of hitch(es), and the angle on which it is based

(d) type of synthetic web material

9-5.5.2 Sling identification shall be done by the sling manufacturer.

9-5.5.3 Maintenance of Sling Identification

Sling identification should be maintained by the user so as to be legible during the life of the sling.

9-5.8.4 Removal Criteria A sling shall be removed from service if damage such as the following is visible ...

(a) missing or illegible sling identification. See Section 9-5.5.

(c) ... charring of any part of the sling;

(d) ... tears, cuts, or snags;

(i) other visible damage that causes doubt as to the strength of the sling.

Incorrect explanations of the cause of the accident

The rated WLL (working load limit) of the slings was exceeded by the load.

The rated WLL for the sling when new—for a straight lift—was 2.0 metric tons [tonnes] = 2000 kilograms = 4410 lb = 2.205 tons. That this sling indeed was rated at 2.0 metric tons is confirmed by its color, green, which is still visible in small areas in spite of the extensive wear. As reported in European Standard EN 1492-1 : 2000 (page 14), the WLL is color coded—violet is 1.0, green is 2.0, yellow is 3.0, etc.

There is also a sling load factor to be applied for other than a vertical basket hitch. (A sling load factor chart can be found in www.liftex.com/slingcare.html) For the configuration of the subject incident, the sling angle from vertical was in the order of 15°; for this the load factor is 1.035.

Since there are two slings used per load, and since the approximate load to be lifted was four times the 1098 lb for each bundle shown in photograph P23L—that is 4392 lb—there would be a larger safety factor for the slings when they are in good condition. (Four bundles of lumber were noted in reference P-10.)

It should be noted that representative samples of the endless webbing slings as manufactured are required to sustain a force at least *seven times* the WLL, according to European Standard EN 1492-1 : 2000, page 22, Sections A.3.1 and A.3.3.1.

There is no indication that there was an unbalanced load *before* the failure of the sling. A small deviation from horizontal orientation of the load would not significantly add to the forces being applied to intact slings.

No jolting of the load while it was being lifted was reported by observers.

In conclusion, the rated WLL (working load limit) of the slings was not exceeded by the weight of the lumber load.

A sharp-edge cut was through the sling.

Captain Ferdinand Bijkerk (deposition 42-22) describes another failure of a sling:

> Q. Do you know what on that occasion caused that sling [in Finland] to break [at the start of the lifting]?
>
> A. A strip around the package. It's a steel strip and it's sharp like a knife. It cut the sling.

Examination of the subject sling shows that the failure was not due to a knife-like cut. Exhibit P-24-D shows the sharp-instrument cut made on the subject sling in order to free Mr. Revak from the load of lumber. A smooth edge was formed by that process.

Exhibits P-24-A, P-24-B, and P-24-C show the failure site. The extended fibers are evidence of a substantially different mode of failure—discussed elsewhere in this report.

Inspection procedures used by Wagenborg and Interforest personnel

Wagenborg Shipping

The Shipboard Operation Manual, Section 12 (Exhibit P-29) states:

- "Report the particulars about the slings … on board (such as numbers delivered, returned and/or damaged) after each departure on the Voyage Report."

- "The ship is responsible for safe cargo operations, so check your slings before and during loading/discharging and remove all unsafe slings.

Exhibit P-30A records that the removed ("scrapped") slings by the Morraborg from 15 to 23 August 2002 (*before* the accident of 8 September) were 12 of 792 total, or 1.52%. Based upon a 1.52% per voyage pre-accident sling removal rate, then the average sling would have been on 66 voyages.

Exhibit P-30C records that the scrapped slings by the Morraborg from 1 to 7 November (*after* the accident of 8 September) were 84 of 437 total returned, or 19.2%. This is more than 12 times the scrapping rate of before the accident.

The exact inspection procedures used by Wagonborg Shipping are uncertain. (For example, do they look to see if the labels on the slings are missing?) However, the inspection procedures—whatever they were—apparently were applied much more assiduously *after* the accident.

On 17 August 2006, almost four years after the accident, Captain Ferdinand Bijkerk (deposition 145-12) was questioned:

Q. If you had inspected this sling before it was used and you had seen the conditions that are shown in these photographs [looking at P-27C—Erb photo], would you have accepted that sling for use or would you have rejected it? [*Powers and Donovan objections.*]

A. I should have refused it because there's some broken part on it, but …

Interforest Terminal

Lief Eriksson testified in his deposition (deposition 19-18):

> Q. Do the longshoremen at Interforest receive any special instruction or training on what to look for when they are inspecting one of these slings?
>
> A. We have a major part of our personnel attending courses on the subject.
>
> Q. Where are these courses given?
>
> A. There's an organization called TYA.
>
> Q. [20-11] … have you ever seen any written documents from that organization that spell out how you are to go about inspecting a sling?
>
> A. Not from that organization, but I do believe that during the course of the training course, there were some pictures [of slings] shown.

Pierre Ogden, Stevedore, testified in his deposition:

- [8-5] that he would not reject a sling with a 1 or 2 mm cut;
- [8-13] that he would reject a sling with a cut of 10 or 20 mm;
- [6-9] that he had no written instructions on inspection, and was shown no pictures; his instruction was by word-of-mouth only from co-workers.

Per Johansson, stevedore, said in his deposition:

- [18-27] that he learned how to inspect a sling from a foreman;
- that there were no written guidelines; and
- that there was no school or training institute provided.

Patrick Mattson, Operations Manager, said in his deposition:

- [7-16] that he received instructions on "how to go about checking the slings" from [he thought] his foreman.

- [8-9] "... in the workshop ... we do have a picture showing how these slings should look like when they are considered deficient and rejected ... some sort of a board that has been produced by Bridan."

- [10-25] That he would not reject the slings shown in Exhibits P-27C and P-27.

Locatum's certification (P-2) states: "This is to certificate that the 468 pieces of endless polyester slings ... have been examined [by Interforest Terminal] according to the rules for continuous supervision of lifting appliances." None of the witnesses who provided depositions knew what these rules were.

COMMENTS

This report may be supplemented if additional information becomes available.

Respectfully submitted,

Robert A. Erb, Ph.D.

By:
ROBERT A. ERB, PH.D.
Fleisher Forensics, Inc.

RAE:cl

LIST OF ENCLOSURES

Enclosure	Image	Description
1	620	Surface abrasion 1.
2	621	Surface abrasion 2.
3	624	Edge damage 1.
4	622	Edge damage 2.
5	610	Failure area.